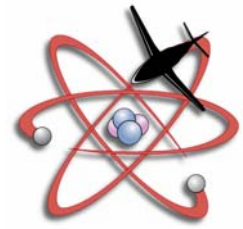# CNS Data Link

## Avionics Manufacturer Perspective
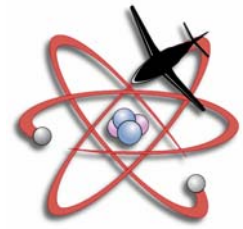
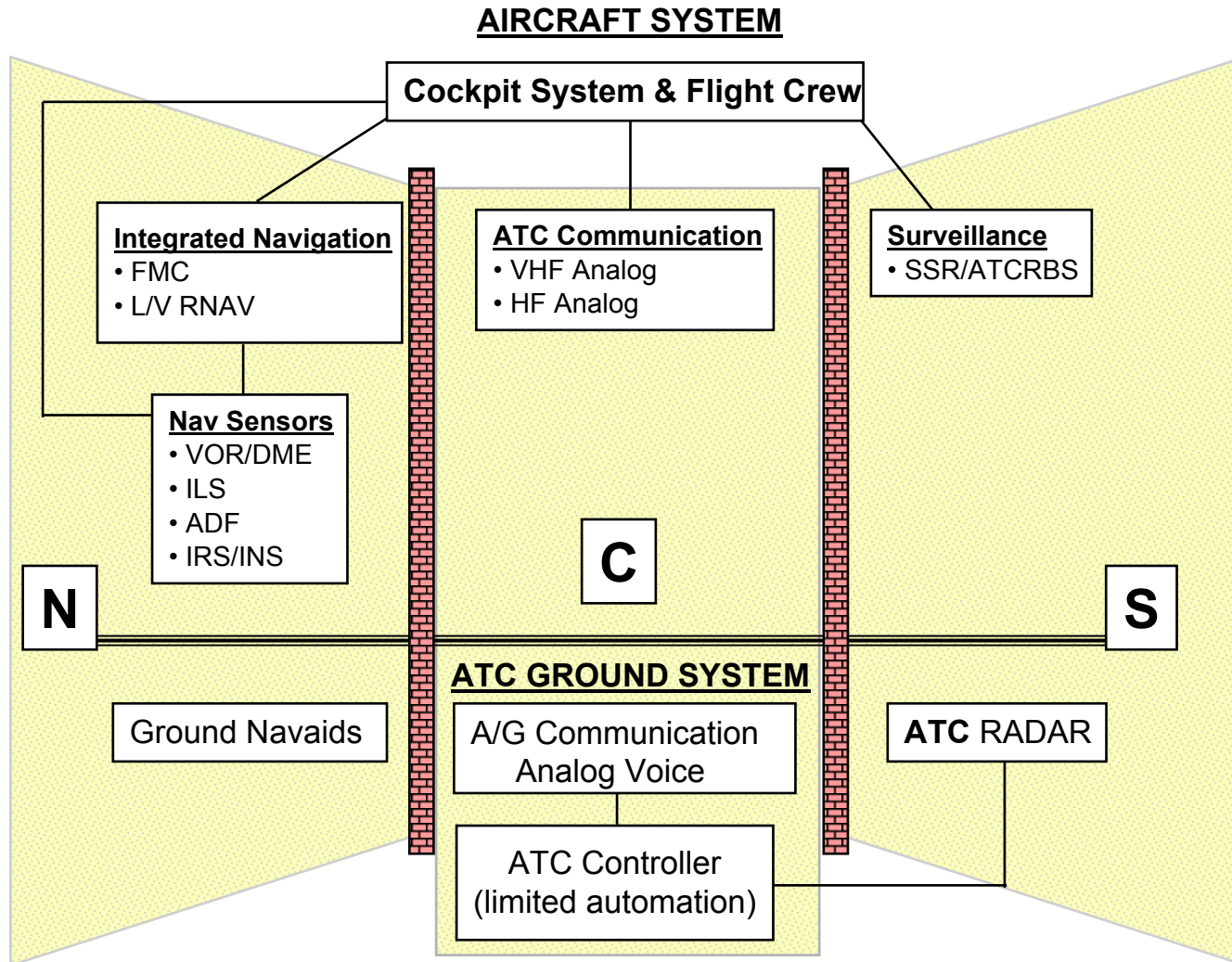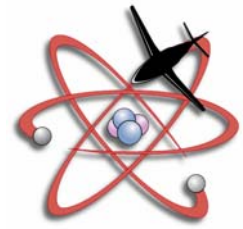**Advanced Technology Center**

**Steve Koczo**

**1 May 2001**

# Agenda

- **Current versus Future Airspace System (CNS / ATM)**
- **Customer's View**
- **CNS Data Link Applications  - Overview**
  - **Communications Characteristics, Trends**
  - **VDL and SATCOM**
- **Example Applications**
  - **Surface Operations**
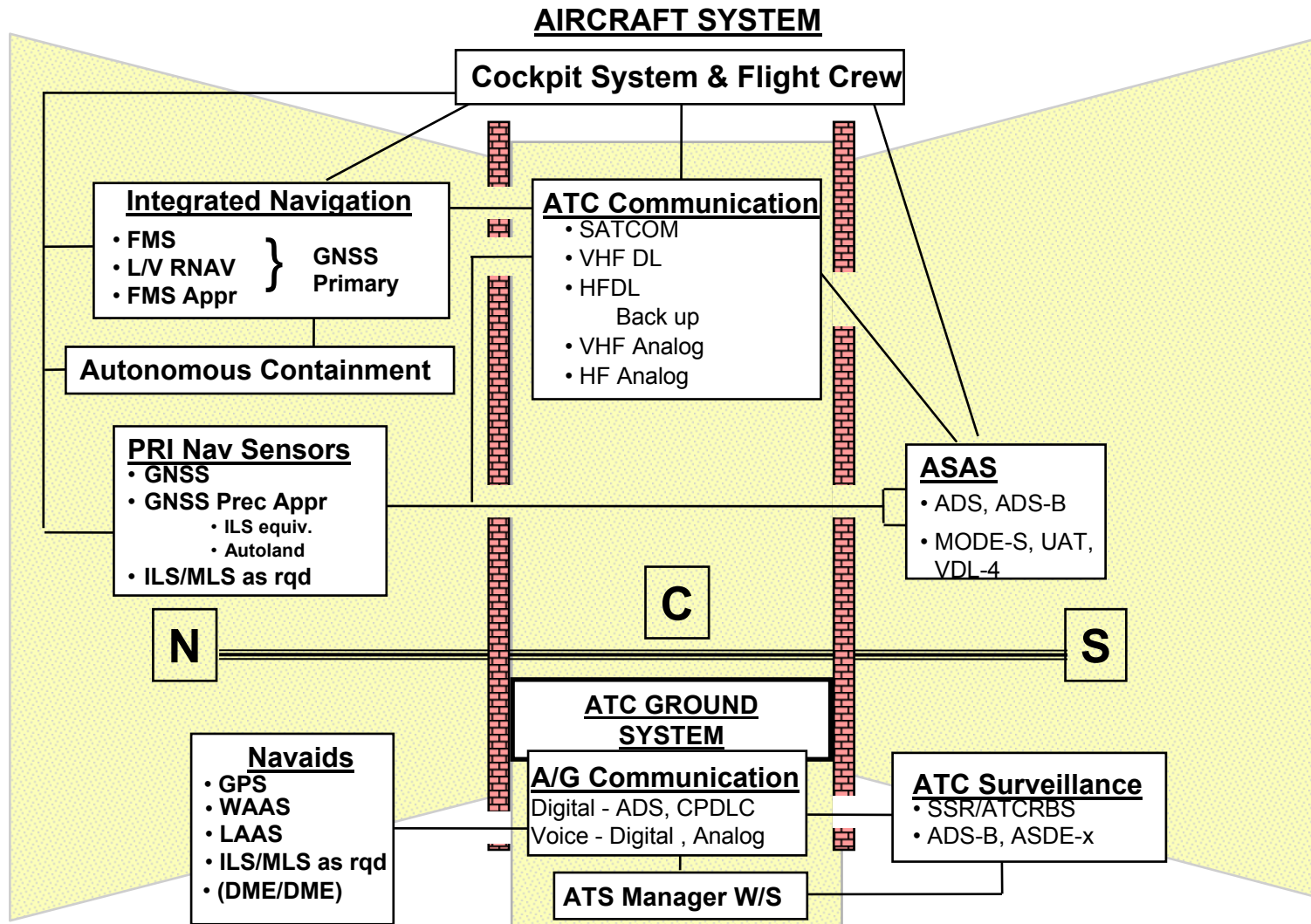  - **Uplink Weather**
- **Summary of Issues**

# Current Air Traffic Control System

**AIRCRAFT SYSTEM**

Cockpit System & Flight Crew

**Integrated Navigation**
• FMC
• L/V RNAV

**ATC Communication**
• VHF Analog
• HF Analog

**Surveillance**
• SSR/ATCRBS

**Nav Sensors**
• VOR/DME
• ILS
• ADF
• IRS/INS

**N**

**C**

**S**

**ATC GROUND SYSTEM**

Ground Navaids

A/G Communication
Analog Voice

**ATC** RADAR

ATC Controller
(limited automation)

# Future Air Traffic Management System

**AIRCRAFT SYSTEM**

**Cockpit System & Flight Crew**

**Integrated Navigation**
- FMS
- L/V RNAV  } **GNSS Primary**
- FMS Appr

**Autonomous Containment**

**PRI Nav Sensors**
- GNSS
- GNSS Prec Appr
  - ILS equiv.
  - Autoland
- ILS/MLS as rqd

**ATC Communication**
- SATCOM
- VHF DL
- HFDL
  Back up
- VHF Analog
- HF Analog

**ASAS**
- ADS, ADS-B
- MODE-S, UAT, VDL-4

**N**  **C**  **S**

**Navaids**
- GPS
- WAAS
- LAAS
- ILS/MLS as rqd
- (DME/DME)

**ATC GROUND SYSTEM**

**A/G Communication**
Digital - ADS, CPDLC
Voice - Digital , Analog

**ATC Surveillance**
- SSR/ATCRBS
- ADS-B, ASDE-x

**ATS Manager W/S**

# Transition Elements



**Comm**      **Surveillance**

DATA

RADAR

VOICE

ADS

GPS

VOR/DME
ILS
IRS

**Navigation**

**Current Air Traffic System**

**Comm**      **Surveillance**

RADAR

DATA

ADS

Decision Support Systems

VOICE

ADS-B

GNSS/GPS
MLS
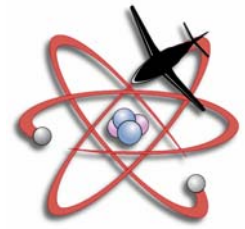FMS/IRS

**Navigation**

**Long-Term Free Flight Vision**

Procedural Separation To Performance Based Separation
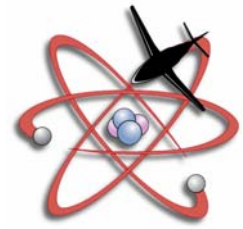
Transition from Ground-Based to Space-Based Navigation

Transition from Voice-Based to Digital Data-Based Communications

Transition from Ground-Based Air Traffic Control to a Managed Environment with Shared Responsibility

# CNS / ATM Environment



SATCOM

GNSS

C

N

Navigation
Satellites

GNSS

N

C

TCAS - ADS-B

S

C

S

LAAS

VHF, HF, Mode S

S

N

Ground Communications Network

| Airline Operations | Passenger Services | Air Traffic Control |

DGNSS
Reference Stations
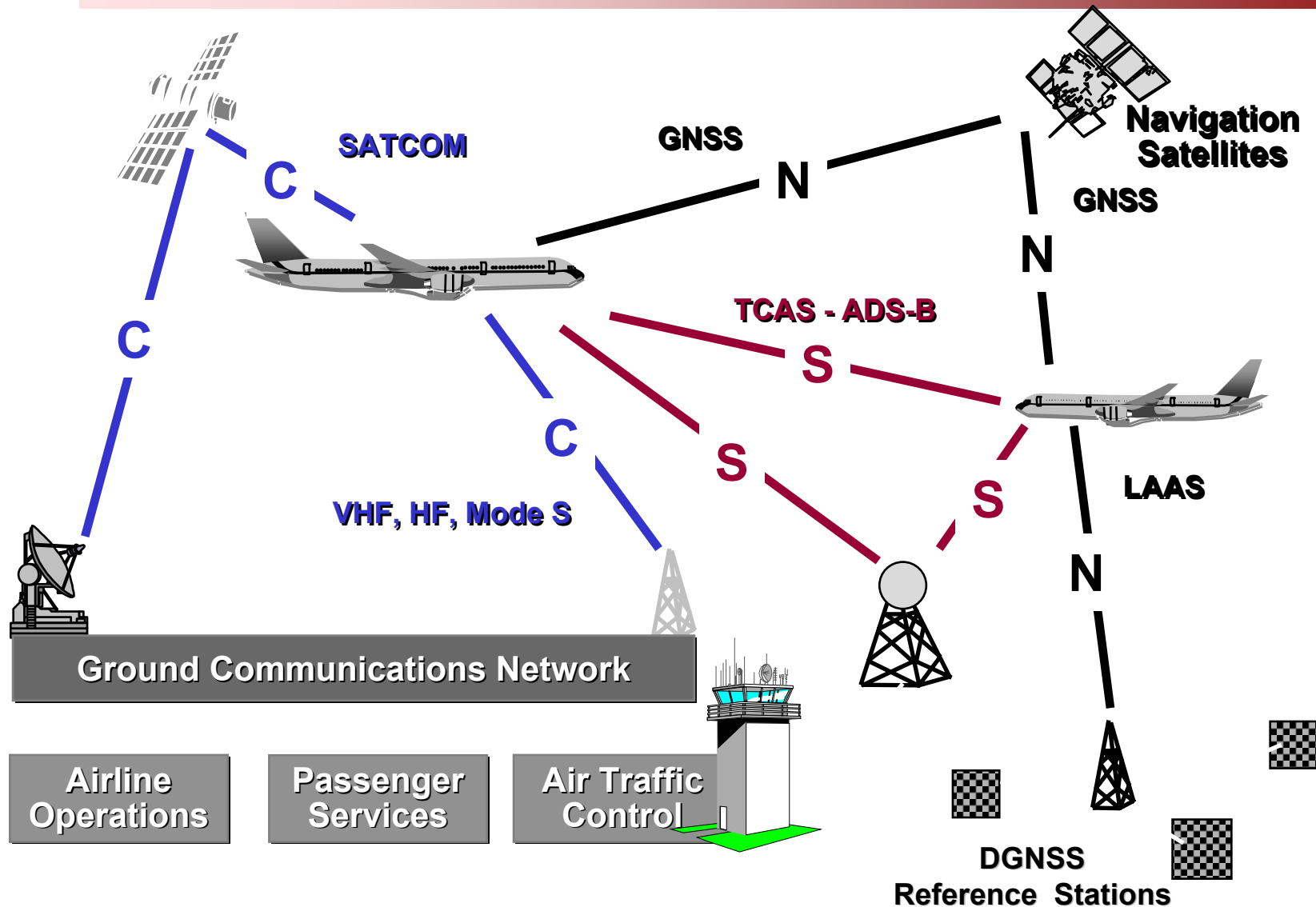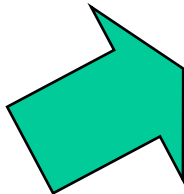
# Our Customers - Diverse Markets, Common Airspace

## Air Transport

**Direct Operating Cost Driven**
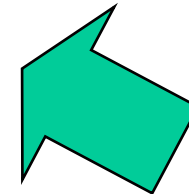**Growth & Flexibility Key Issues**
**Will Drive New Airspace Definition**
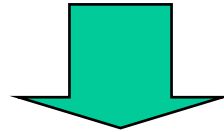
## Common Airspace

**CNS/ATM Transition Driven**
**Common Rules**
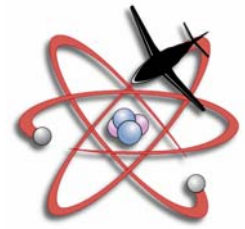**Common Function/Applications**

## Government

**Global Mission Capability**
**Commercial Airspace Compatible**
**COTS Desire**

## Commuter/Business

**Follow Air Transport Technology**
**Convergence With Airline Ops**
**Integrated Solutions At OEM**

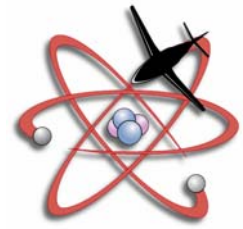# What Will Make Customers Buy CNS / ATM?

- **Positive Cost-Benefit Analysis**
  - Short Term Payback Oriented
  - May Work For Incremental Enhancements
  - Must Demonstrate Business Case
- **Cost Avoidance**
  - Must Establish Credible Future Scenario
  - Longer Term Investment Oriented
- **Competitive Position**
  - Project Impact To Revenue
  - Longer Term Investment Oriented
- **Fear Factor**
  - Denial Of Access To Airspace - via Mandates Or "Segregated Airspace"

# Key Customer Requirements

- **Value-Added Solutions to Operational Problems**
  - **Short-Term Payback**

- **Highly Reliable Avionics**
  - **Meet or Exceed Safety and Performance Requirements**
  - **High MTBF, Integrity, Low No-Fault-Found**

- **Low-Cost, Simplified Upgrades to Future Capability**

- **Reduced Physical Impact on Aircraft**
  - **Reduced Aircraft Wiring, Fewer Antennas, Reduced Weight / Size, Lower Power, Passive Cooling**
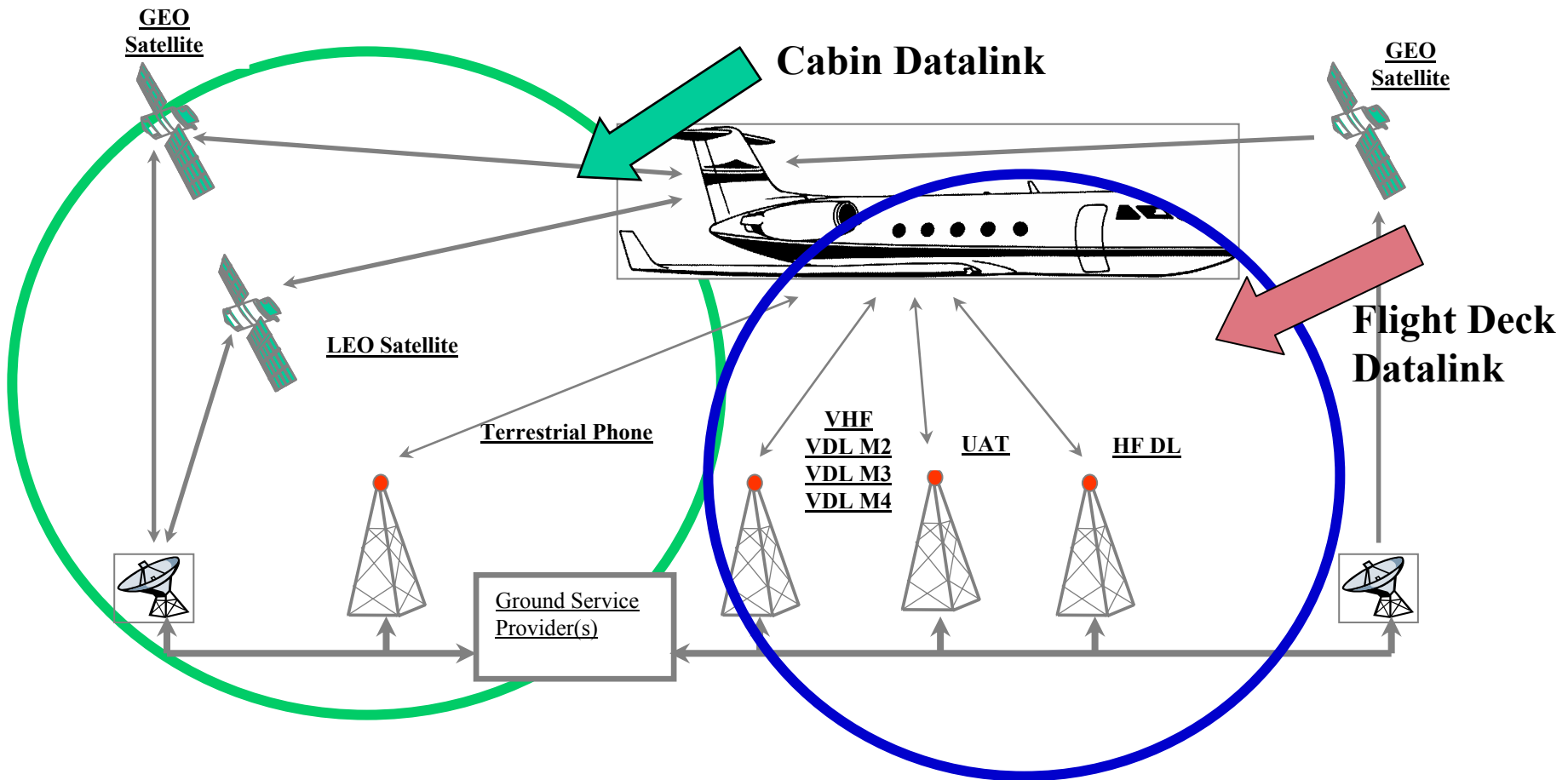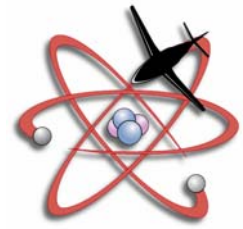
- **Maintainable**
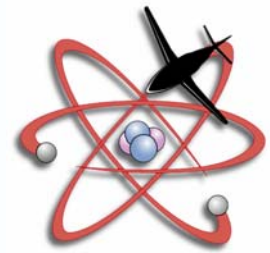
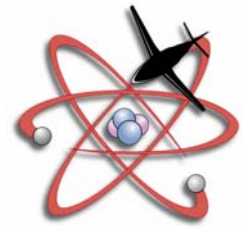# CNS Data Link Applications - Overview
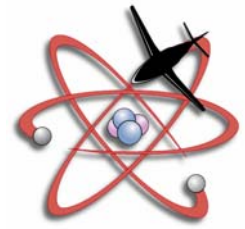
# Data Link - Cabin & Flight Deck

# CNS Data Link - Applications Overview

| Service Category | CNS Application | Candidate Data Link(s) | Type of Service |
|---|---|---|---|
| Air Traffic Control (ATC) | CPDLC | VHF Data Link (VDL) Mode 2, 3; SATCOM, HF DL | Addressed two-way data link, networked via ATN, strategic comms |
| | ADS-A / ADS-C | SATCOM, HF DL, VDL | Addressed two-way data link, ATN, strategic comms |
| Air Traffic Services (ATS) | FIS, FIS-B <br> - Predeparture Clearance <br> - Digital ATIS, <br> - Uplink Weather, <br> - Graphical NOTAMS, <br> - Etc. | VDL, UAT, Satellite Communications | Broadcast and addressed comms, higher bandwidth |
| Surveillance | ADS-B, TIS-B | Mode-S, UAT, VDL-4 | Broadcast surveillance reports, tactical |
| Navigation | DGPS/DGNSS | VDL | Broadcast navigation uplink / diff. corrections, tactical |
| AOC/AAC | Various airline comms | VDL, SATCOM, HF DL | Addressed two-way data link, ATN, strategic comms |
| APC | Cabin telephone, information, entertainment | Satellite communications, VDL | Passenger services; high-bandwidth broadcasts, addressed comms |
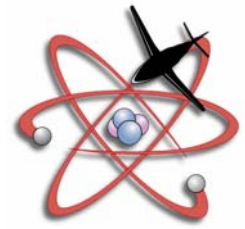
# Data Link Comm Characteristics

- **Increasing Number of Communication Services / Applications are Vying for Limited Data Link Resources**
- **Range of Required Communications Performance**
  - **Coverage (Terrestrial, Oceanic, Long / Short Range)**
  - **Broadcast or Addressed**
  - **Latency (Low for Tactical, Moderate for Strategic)**
  - **Bandwidth, Data Rate**
  - **Specific versus Networked (ATN) Communications**
  - **Range of System Criticality (Integrity / Continuity / Availability)**
    - **ATC / ATS Comms versus APC Comms**
  - **Spectrum Use / Assignment (C, N, S, other)**

# CNS Data Link Communications - Trends

- **Advanced CNS Applications are Moving Toward More *Autonomous, Multi-Thread* Communications**
  - **Multiple Data Link Services via Same Data Link Resource / Media to Support Several Applications**
    - **E.g., Capstone Utilizes UAT for ADS-B and FIS-B, i.e., Supporting Applications for Free Flight and Air Traffic Management (ATM) lead to Multi-Thread Communications**
    - **VDL-4 Simultaneous Use for CPDLC, ADS-B, Etc**
- **Planned VDL-2 /3 and INMARSAT SATCOM to Provide Current High-Bandwidth Standards (31.5 kbps & 64 kbps, respectively)**
  - **Particularly for Air Transport Category Aircraft**
  - **UAT Role for General Aviation (?)**
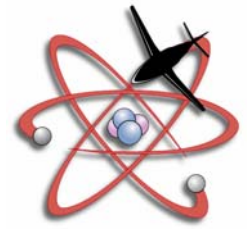
# CNS Data Link Communications - Trends (ctd)

- **Potential for Significant Increase in VDL Resource Use**
  - CPDLC, FIS-B, AOC/AAC, ADS-B (VDL-4), etc.
  - High-Data Rate Waveforms Stressing Robustness for Frequency Reuse and Isolation (Desired/Undesired)
  - Multiple VDL TXs/RXs On Aircraft Creating Problem With Isolation, I.e., Self-Interference
    - Aircraft Typically Utilize 3 VHF/VDL Radios; Could Grow Considerably Due to ADS-B (VDL-4) and FIS-B Use

- **Future High-Bandwidth Satellites Being Considered for Wide-Coverage Services of Weather Data, and Cabin Information Services (Broadcast and Addressed)**
  - Aviation Unable to Compete with Commercial Use for These High-Value Resources (e.g., XM radio)
  - Integrity Issue for Some Avionics Applications
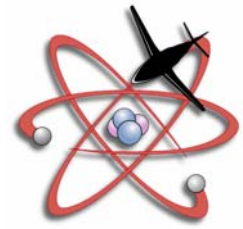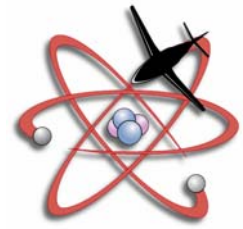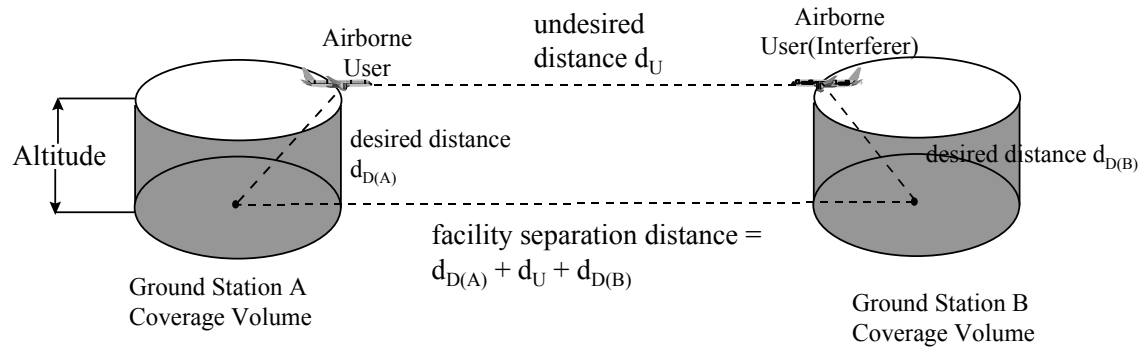
# Aircraft Antennas - VHF Antenna Isolation
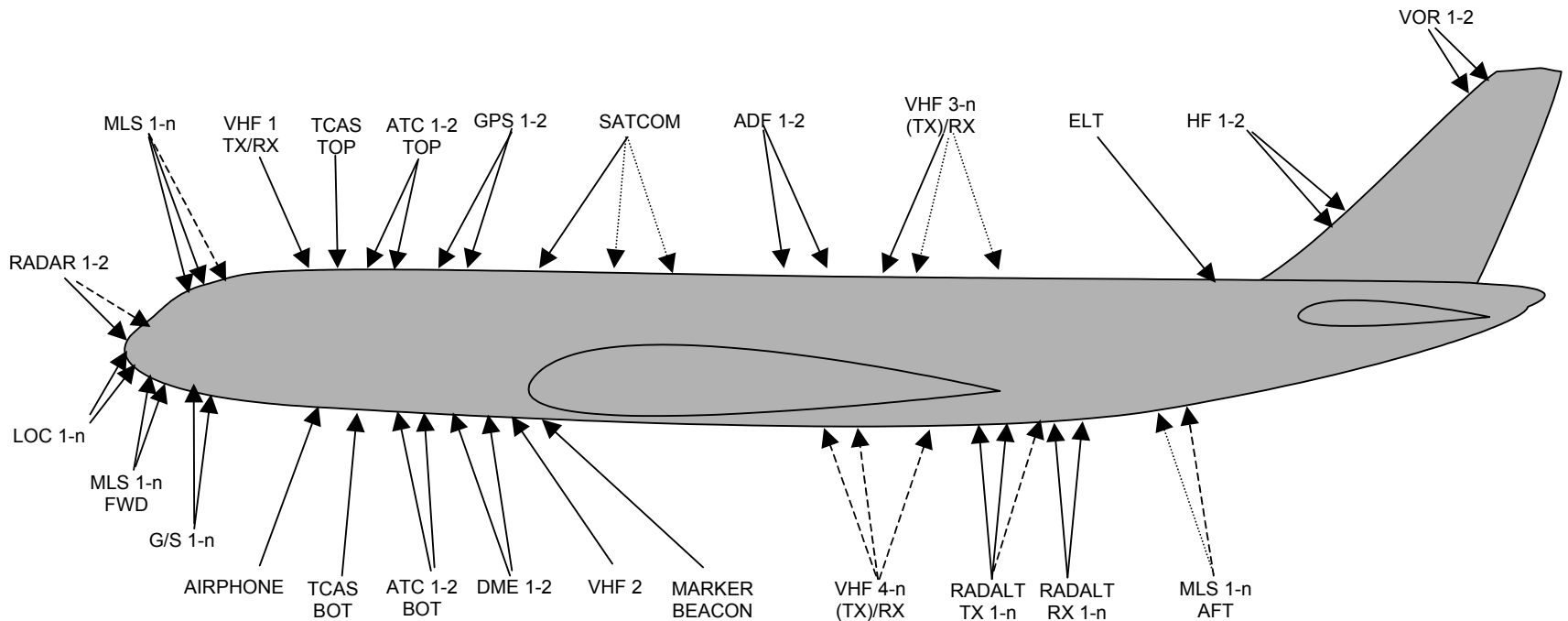


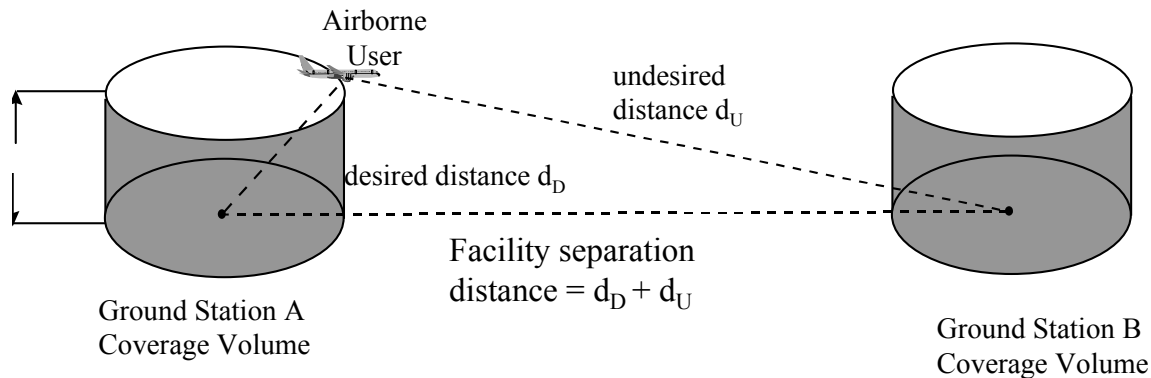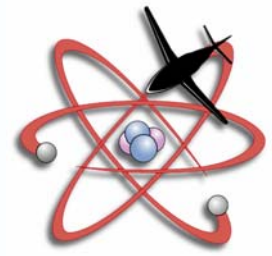**Antenna Considerations Impact Radio Designs & Architecture**

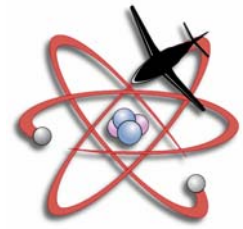# Co-Channel Interference - Reuse Distance



**Facility Separation for Two-Way Data Link Communications**



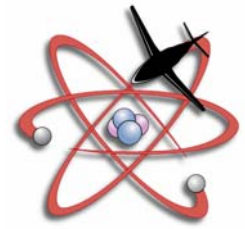**Facility Separation for Ground Broadcast Data Link Communications**
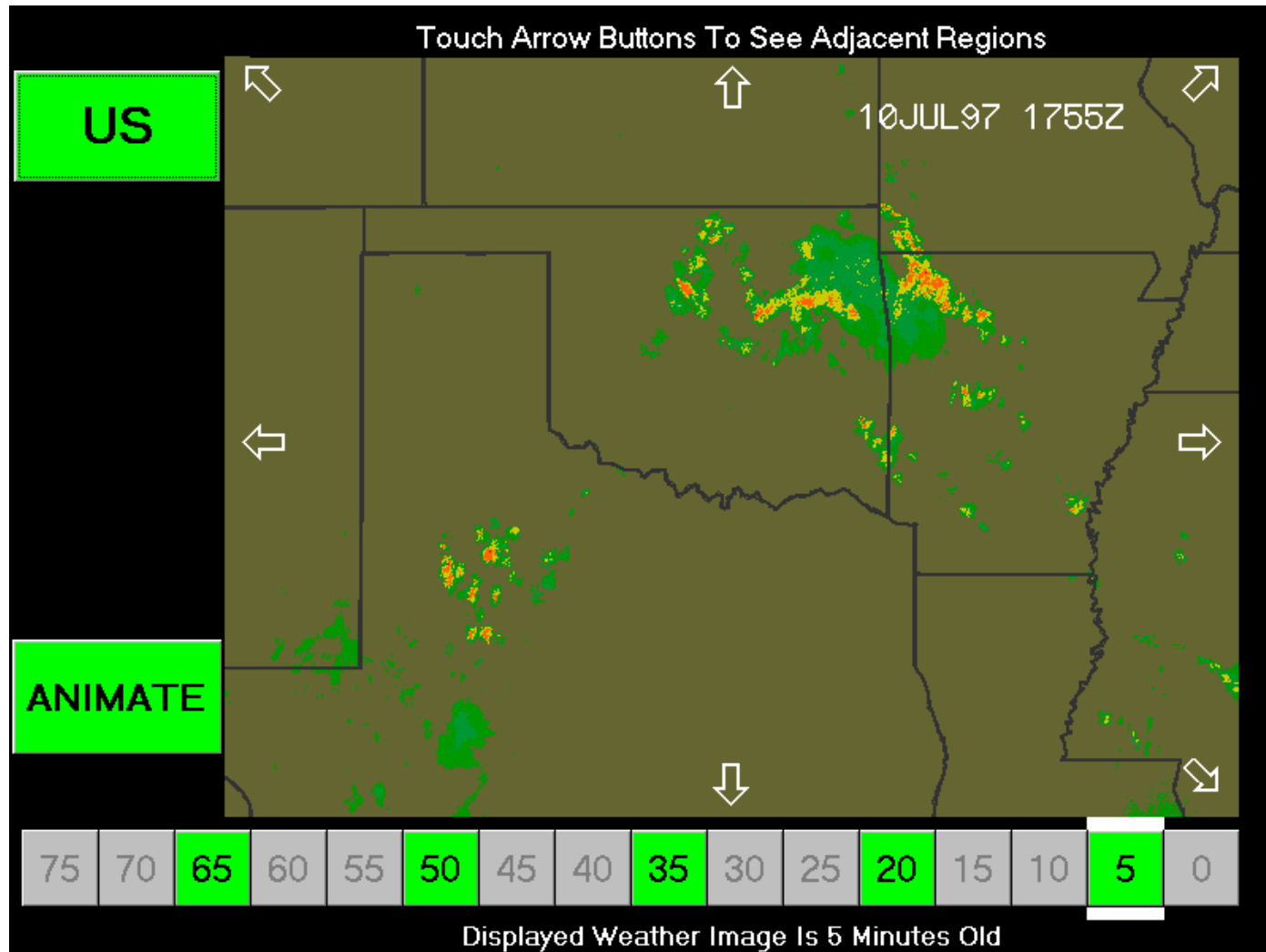
# Example Applications

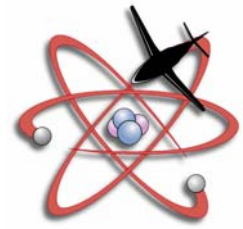# Low Visibility Landing and Surface Operations (LVLASO)



T-NASA Display Format –
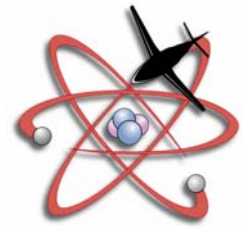NASA Langley/Ames

# Uplink of Weather Information

# Summary of Issues

- **CNS Data Links are Becoming More Pervasive**
  - — **Serve as Backbone for Advanced CNS/ATM Apps**
- **Proper Allocation of Data Link Services to Data Links**
- **Data Link Interoperability Among Users**
- **Integrity Assurance of Autonomous, Multi-Thread Comms**
- **Spectrum**
  - — **Must Provide Needed Data Capacity / Bandwidth**
  - — **Protect Existing Aviation Spectrum**
  - — **Develop Future Data Links (Waveforms, Protocols) that Co-Exist / Share Spectrum with Legacy Systems**
    - — **E.g., 960 MHz to 1215 MHz**
- **Protection Against Ultra Wideband Interference**

# Summary of Issues

- **Multiple VDL TXs/RXs on Aircraft**
  - **Ability to Achieve Sufficient Isolation to Avoid Self-Interference**
    - **Impact on Radio Design / Architecture**
- **Aviation Industry's Access to Wide Coverage, High-Bandwidth Satellite Data Links for Safety Services (e.g., Uplink Weather, etc)**
  - **Low-Cost Satellite Antenna and Radio Avionics**
  - **Difficult Economic Case Against Commercial Users (E.g., XM Radio, SIRIUS)**
    - **Need for Government Sponsorship of Such Services ?**
- **Resolution of ADS-B Data Link**
  - **Multi-Link Environment? Interoperability?**